18

MAGNETISM OF THE IRON PARTICLES AS REVEALED BY ELECTRON DIFFRACTION

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The path of an electron beam is deflected in a magnetic field as the result of the Lorentz effect. This effect is observable in the diffraction pattern obtained from a ferromagnetic substance.

The rather soft electrons (about 50 KV) graze the surface of matter, whereas the hard electrons (about 200KV) are able to tunnel through a thick particle (thickness: about 3000 Å) (Yamaguchi, 1957, Yamaguchi and Takeuchi, 1957).

These two experiences imply that the alternative use of the soft and the hard electrons is of use for studying the surface magnetism of a given particle as compared with the interior magnetism of itself by means of diffraction.

Iron powder was here employed as a specimen for the experiment. The iron particles were magnetically attracted at the sharp edge of a razor blade acting as permanent magnet (remanence: about 10000 gauss). In this way these iron particles were kept in the saturation induction. An electron beam grazed these magnetized particles to give rise to a diffraction pattern.

A process of double exposure was carried in order to measure the Lorentz effect caused by the specimen. The diffraction pattern of a non-ferromagnetic gold foil was first photographed, and then that of the specimen was superimposed upon it. In this process, the position of the photographic plate as well as the wavelength of the incident beam were kept constant. Fig. 1 is a double diagram obtained in this process with the soft electrons (wavelength: 0.0479 Å). It is remarkable in this diagram that the diffraction rings from the reference gold foil and those of the specimen are eccentric as the result of the Lorentz effect. The ring eccentricity measurable in Fig. 1 makes it possible to calculate the magnetic induction at the surface of the specimen. Fig. 2 is a double diagram obtained with the hard electrons (wavelength 0.0277 Å) from the same spot of the specimen as for Fig. 1. There is again the ring eccentricity in this diagram. This diagram informs us of the magnetic induction found in the interior of the particle specimen. We have a relation between Figs. 1 and 2 :

$$\frac{Z_1}{Z_2} = \frac{\lambda_1 B_s}{\lambda_2 B_i} \qquad \cdots \quad (1)$$

where Z_1 and Z_2 mean the ring eccentricity in Fig. 1 and that in Fig. 2, λ_1 and λ_2 mean the wavelength in Fig. 1 and that in Fig. 2 (0.0479 and 0.0277 Å), and B_s and B_i mean the surface and the interior inductions of the iron particles. From Figs. 1 and 2 we measure $Z_1 / Z_2 = 1.59$. According to Eq. (1), therefore, we obtain

$$B_s/B_i = 0.92$$

or

$$B_s < B_i.$$

FIG. 1. A double diagram from the magnetized specimen and gold, taken with the soft electrons. Wavelength: 0.0479Å. Camera length: 495 mm. Positive enlarged 2.3 times.

FIG. 2. A double diagram taken with the hard electrons. Wavelength: 0.0277Å.

The diffraction rings characteristic of the oxide (Fe_3O_4) in Fig. 1 with the soft electrons are distinctly more intense than those in Fig. 2 with the hard electrons. This fact verifies readily that the surface of the iron particles is covered with the oxide. The induction of this oxide is lower than that of pure iron. It is, therefore, reasonable for the present specimen that the surface induction B_s is lower than the interior induction B_i. A model of the iron particle under question is illustrated in Fig. 3.

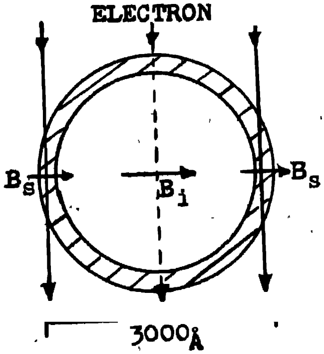

FIG. 3. The magnetic structure of the iron particle as revealed by electron diffraction. B_i and B_s mean the interior and the surface induction respectively.

REFERENCES

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